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(54) CARBON NANOTUBE ENCLOSING FOREIGN SUBSTANCE AND ITS PRODUCTION

(57)Abstract:
PURPOSE: To enable the introduction of a foreign substance from the tip of a carbon nanotube by depositing the vapor of the foreign substance on the tip of the carbon nanotube and introducing the foreign substance into a hollow hole present in the center of the tube according to the thermal diffusion.
CONSTITUTION: The vapor of a substance other than carbon, e.g. lead 2 is deposited on the tip of a carbon nanotube 1 and further introduced from the tip of the carbon nanotube 1 into a hollow hole present in the center of the tube according the thermal diffusion. Thereby, the carbon nanotube enclosing the foreign substance is produced. A metal, a superconductor, a semiconductor, a magnetic substance, an organic molecule, a gas, an alkaline metal, etc., are cited as the substance to be enclosed therein. The carbon nanotube enclosing the foreign substance

can be expected of practical use as a basic material for devices using a quantum size phenomenon produced within a nanometer region, a basic element for electronic elements having ultrahigh mobility or a high-density recording material reflecting the completeness of the structure of the carbon nanotube or a new electronic material and further application as a new material in the chemical industrial aspects.

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CLAIMS

[Claim(s)]

[Claim 1] The nature endocyst carbon nanotube of a foreign matter characterized by carrying out the endocyst of the matter other than carbon to the hole of the hollow which exists at the core of the carbon nanotube of an embedded structure.

[Claim 2] The nature endocyst carbon nanotube of a foreign matter characterized by the matter by which endocyst is carried out being a metal or a superconductor in the nature endocyst carbon nanotube of a foreign matter according to claim 1.

[Claim 3] The nature endocyst carbon nanotube of a foreign matter

characterized by the matter by which endocyst is carried out being a semi-conductor in the nature endocyst carbon nanotube of a foreign matter according to claim 1.
[Claim 4] The nature endocyst carbon nanotube of a foreign matter characterized by the matter by which endocyst is carried out being the magnetic substance in the nature endocyst carbon nanotube of a foreign matter according to claim 1.
[Claim 5] The nature endocyst carbon nanotube of a foreign matter characterized by the matter by which endocyst is carried out being an organic molecule in the nature endocyst carbon nanotube of a foreign matter according to claim 1.
[Claim 6] The nature endocyst carbon nanotube of a foreign matter which the matter by which endocyst is carried out is a gas in the nature endocyst carbon nanotube of a foreign matter according to claim 1, and is characterized by this gas molecule sticking to the wall of a nanotube.
[Claim 7] The nature endocyst carbon nanotube of a foreign matter characterized by the matter by which endocyst is carried out being alkali metal in the nature endocyst carbon nanotube of a foreign matter according to claim 2.
[Claim 8] The manufacture approach of the nature endocyst carbon nanotube of a foreign matter characterized by introducing into the hole of the hollow which is the manufacture approach of the nature endocyst carbon nanotube of a foreign matter one to claim 7 publication, vapor-deposits matter other than carbon at the tip of a carbon nanotube, and exists at the core of a tube from the tip of a carbon nanotube by thermal diffusion further.
[Claim 9] The manufacture approach of the nature endocyst carbon nanotube of a foreign matter which is the manufacture approach of the nature endocyst carbon nanotube of a foreign matter according to claim 8, and is characterized by introducing matter other than carbon into the hole of the hollow which exists at the core of a carbon nanotube after that at the same time it contacts a carbon nanotube to oxygen, ozone, hydrogen, atomic hydrogen, etc.
[Claim 10] The manufacture approach of the nature endocyst carbon nanotube of a foreign matter which is the manufacture approach of the nature endocyst carbon nanotube of a foreign matter according to claim 8, and is characterized by introducing matter other than carbon into the hole of the hollow which exists at the core of a carbon nanotube after that at the same time it impresses the direct-current high voltage to a carbon nanotube and causes corona discharge.
[Claim 11] The manufacture approach of the nature endocyst carbon

nanotube of a foreign matter which is the manufacture approach of the nature endocyst carbon nanotube of a foreign matter one to claim 7 publication, and is characterized by making matter other than carbon act on a carbon nanotube at an elevated temperature with a gas compound, and introducing the matter.

[Claim 12] The manufacture approach of the nature endocyst carbon nanotube of a foreign matter characterized by being the manufacture approach of the nature endocyst carbon nanotube of a foreign matter according to claim 11, and the gas compound to be used being disilane gas.

[Claim 13] The manufacture approach of the nature endocyst carbon nanotube of a foreign matter characterized by being the manufacture approach of the nature endocyst carbon nanotube of a foreign matter according to claim 11, and the gas compound to be used being the mixture of an arsine and triethylgallium.

[Claim 14] The manufacture approach of the nature endocyst carbon nanotube of a foreign matter which is the manufacture approach of the nature endocyst carbon nanotube of a foreign matter 11 to claim 13 publication, and is characterized by irradiating light at coincidence when making a gas compound act on a carbon nanotube.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the exotic material which hid possibility of being used in large fields, such as the electronics industry and the chemical industry, about the nature endocyst carbon nanotube of a foreign matter containing the quality of a foreign matter, and its manufacture approach into the hole of the hollow in the core of the carbon nanotube of the microfilament configuration which has nano meter size, and its manufacture approach.

[0002]

[Description of the Prior Art] The cylinder with which the carbon nanotube rounded off the graphite-like carbon atomic plane has one piece or the fibrous structure partly arranged in the shape of a nest, and the diameter is the very minute matter of the size of NANOME-TORUO-DA -. Although, as for the carbon fiber more than micron size, the diameter

was known for many years until now, the tube of a NANOME-torr field was clarified for the first time by the report in 1991 [Nature (Nature) 1991, 354 volumes, and pp. 56-58], and the diameter has attracted the big attention as a 1-dimensional electric conduction line, a catalyst, and a super-strengthening structure ingredient from all over the world. The electric physical properties of each carbon tube which form the nest condition of a carbon nanotube especially be investigate (a physical review letter magazine (Physical Review Letter) , 1992 , 68 volumes , pp-1579-1581) , and it have a big charm of this matter that it be showed clearly that even the semi-conductor in which the electrical property of a carbon nanotube have the band gap of various magnitude from a metal changed depending on that diameter and pitch of the helical structure .

[0003]

[Problem(s) to be Solved by the Invention] Thus, the carbon nanotube itself has attracted attention as new materials with which it is full of charm. however, inside, although the carbon nanotube itself might be used for the adsorbent as it was until now or it might sometimes argue about the idea used as a composite material mixed with other ingredients, the present condition is not found out about the exotic material based on a carbon nanotube, and its process.

[0004] This invention is made for the purpose of offering a new material on the basis of the structure of a carbon nanotube.

[0005]

[Means for Solving the Problem] The result to which this invention person etc. advanced examination wholeheartedly paying attention to the structure of this carbon nanotube, It succeeds in introducing the quality of a foreign matter from the tip of a carbon nanotube using an alternative reaction with the melt of different matter from the tip of a carbon nanotube, and carbon. Moreover, when the matter with the high melting point of a solid state also used gas compounds, such as the hydride, it found out that found out that the quality of a foreign matter can be easily introduced from the tip of a carbon nanotube, and it was possible, and resulted in this invention. [of the nature endocyst carbon nanotube of a foreign matter which is new materials]

[0006] As matter by which endocyst is carried out, a metal, a superconductor, a semi-conductor, the magnetic substance, an organic molecule, a gas, alkali metal, etc. can be chosen.

[0007] As a metal, elements, such as samarium, a gadolinium, a lanthanum, iron, cobalt, and nickel, the mixture of those, etc. can be used as elements, such as lead, tin, and a gallium, and a semi-conductor as

matter, such as lead, tin, copper, an indium, and mercury, and a superconductor as the magnetic substance, such as silicon, germanium, gallium arsenide, a zinc selenide, and zinc sulfide, for example. Moreover, as an organic molecule, organic-coloring-matter molecules, such as organic molecule semi-conductors, such as naphthalene, an anthracene, a phenanthrene, a pyrene, and perylene, and cyanine dye, and B-carotene, can be used. Moreover, as a gas, a lithium, sodium, a potassium, a rubidium, and caesium can be used as molecules, such as hydrogen fluoride, methane, and ethane, and an alkali metal.

[0008] The combination can be used for the hydride of elements for which it asks, such as a silane, a disilane, germane, a dichloro silane, an arsine, phosphoretted hydrogen, hydrogen selenide, a hydrogen sulfide, triethylgallium, dimethyl zinc, and a hexafluoro tungsten, a chloride, fluoride, an alkoxy compound, and an alkyl compound list as a gas compound to be used.

[0009] this invention person etc. considered the tip of the usual carbon nanotube that it is important to open the tip of a carbon nanotube, in order to introduce the quality of a foreign matter through a reaction with the tip of a carbon nanotube paying attention to having closed (a NEICHUA-magazine (Nature), 1992, 356 volumes, pp 776-778). A means to open the tip of a carbon nanotube impresses the high voltage at the approach and carbon nanotube tip which contact reactant gas and etch a tip alternatively, and can consider how to contact a lifting, the approach of destroying a tip, and a reactant high liquid in corona discharge, and etch a tip etc. This invention provides coincidence also with the manufacture approach of making the nature endocyst carbon nanotube of a foreign matter, by contacting the gaseous compound which heat-treats by vapor-depositing the quality of a foreign matter at the tip of a carbon nanotube, or contains the quality of a foreign matter at it after a reaction in parallel with the reaction which opens the tip of the above carbon nanotubes. When light was furthermore irradiated on the occasion of the reaction of the tip of a carbon nanotube, and a gas compound, the nature endocyst carbon nanotube of a foreign matter found out being obtained more easily.

[0010]

[Function] In a carbon nanotube, the tube in the core of a nest-like cylinder is several angstroms or more in diameter, and there is cylinder-like space in this part. If a metal, a superconductor, a semi-conductor and the magnetic substance, or the organic molecule and gas that are another nature solid-state of a foreign matter can be introduced into this space and the nature endocyst carbon nanotube of a

foreign matter can be made, it is expected as composite material or an ingredient using the property which the endocyst matter itself has in addition to the material property which the carbon nanotube itself has that the applicable field of a carbon nanotube will spread. That is, the various new physical properties resulting from the 1-dimensional nature and the integrity of structure which a carbon nanotube has, or its configuration are expected. For example, the activity as a next-generation electronics ingredient is expected as the basic material using the quantum size effect phenomenon which becomes remarkable in a NANOMETORU field of a device, or a basic material of the high-speed electronic device of high mobility originating in the integrity of the structure of a carbon nanotube. However, as for such new matter, idea ****** were not actually made until now, either.

[0011] Since the carbon five-membered ring existed at the tip of a carbon nanotube, using the active spot of a five-membered ring, when making the quality of a foreign matter react, the tip of a carbon nanotube opened the artificer etc., and he considered from there that the quality of a foreign matter could introduce into the hole which exists at the core of a carbon nanotube, and resulted in this invention as a result of various trial. On the other hand, since all the side faces of a carbon nanotube are made of six membered-rings, even if structure has integrity and it contacts the quality of a foreign matter, the structure of a carbon nanotube does not break. Moreover, between the layers of each tube which makes an embedded structure, the intercalation of the quality of a foreign matter is carried out, and it is not introduced. Although the graphite-like carbon flat surface where this spreads between each layers two-dimensional (x-y side) in the case of usual graphite is connected with Van der Waals force, it spreads somewhat freely in the direction where an interlayer spacing is perpendicular to a x-y side. Therefore, the quality of a foreign matter can introduce between layers, and can build an intercalation compound. However, in the case of a carbon nanotube, the tube which carried out the shape of a cylindrical shape respectively is firm, the path of the cylinder is structurally fixed to it, and an interlayer spacing hardly changes. For this reason, generally the intercalation compound with which the quality of a foreign matter enters between the layers of a carbon nanotube is not made. However, since the hole of the hollow which exists at the core of a carbon nanotube is magnitude which the quality of a foreign matter puts in, it can form the nature endocyst carbon nanotube of a foreign matter with which the quality of a foreign matter was got blocked.

[0012] In fact, according to the synthetic approach of a carbon nanotube reported conventionally, a carbon nanotube is compounded first. A suitable quantity of the quality of a foreign matter is vapor-deposited at the tip of this carbon nanotube. Then, it heats and maintains for a while under atmospheric air at the temperature more than the melting temperature of the quality of a foreign matter. Then, the tip of a carbon nanotube reacts with the quality of a foreign matter, and is destroyed, and the carbon nanotube which the tip opened is formed. It is thought that the quality of a melting condition foreign matter flows in, and the nature endocyst carbon nanotube of a foreign matter is formed from this open place into the hole of the hollow which exists at the core of a carbon nanotube.

[0013] As quality of a foreign matter, since the hole of the hollow of the core of a carbon nanotube has the diameter of about 5A or more, various matter, such as a metal, a semi-conductor, and the magnetic substance, and the mixture of those can be used for it. As a carbon nanotube to be used, although the bore of an inside tube can use various things most, it is desirable for the bore diameter of the hollow which exists at the core of a carbon nanotube from a viewpoint of a quantum device ingredient of using the phenomenon produced in a NANOMETORU field to use a carbon nanotube 10 nanometers or less.

[0014] When a gaseous compound was made to contact and the endocyst of the metal was carried out, as a gaseous compound to be used, it turned out that the hydride is good. The hydrogen content child who generates this during the nature endocyst carbon nanotube generation of a foreign matter is because it is easily excludable out of the system of reaction.

[0015] Moreover, when contacting a gas compound at the tip of a carbon nanotube, it found out that a reaction was promoted more and the nature endocyst carbon nanotube of a foreign matter tends to be made by irradiating light. As wavelength of the light to be used, the thing of a 200-400-nanometer field is desirable. This is because a carbon nanotube cannot receive damage from this during an optical exposure as it is short wavelength, and the reaction at a gaseous compound and the tip of a carbon nanotube cannot fully be promoted from this as it is long wavelength.

[0016]

[Example]

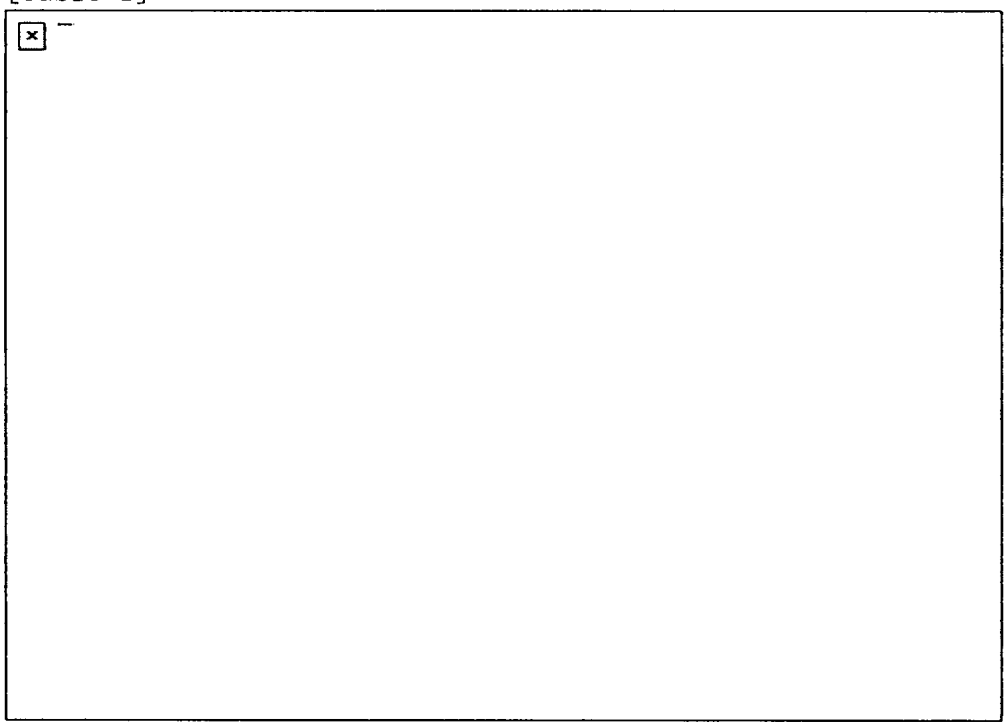
(Example 1) Drawing explains the example of this invention below. The carbon nanotube used for the experiment was made by using a carbon rod with a diameter of 10mm as a cathode in the helium ambient atmosphere of 500Torr(s), and making it discharge by direct-current 20V as a positive

electrode using a 6mm carbon rod. The made carbon nanotube which carried out such was carried on the support grid substrate for electron microscopes, and lead was vapor-deposited to 50-nanometer thickness with the evaporation rate of 5A/s with electron ray vacuum deposition in the vacuum deposition machine. Although it was observed that lead has adhered to the tip and side attachment wall of a carbon nanotube in the shape of a particle when this condition was observed with the electron microscope, in the carbon nanotube, the quality of a foreign matter was not contained. Then, this substrate was put into the heating furnace under atmospheric air, and it heated at 350 degrees C for 30 minutes. Then, when again observed with the transmission electron microscope, it was checked that lead 2 entered from the tip into the tube of a carbon nanotube 1 which has the inside diameter of 20 nanometers most as shown in drawing 1 , and the nature endocyst carbon nanotube of a foreign matter which connoted lead 2 is made.

[0017] (Example 2) It experimented by using tin, copper, and samarium instead of lead like the example 1. This result is shown in Table 1.

[0018]

[Table 1]



[0019] (Example 5) It carried out using naphthalene by conducting an organic molecule the same experiment as an example 1. 50 nanometers of

naphthalene were vapor-deposited with the resistance heating method to the carbon nanotube placed on the grid substrate. After heat-treating this substrate at 150 degrees C with a heating furnace, when transmission electron microscope observation was carried out, the organic intramolecular package carbon nanotube of a carbon nanotube which entered only inside most was checked for naphthalene.

[0020] (Example 6) It carried out using hydrogen fluoride by conducting a gas the same experiment as an example 1. The carbon nanotube placed on the grid substrate was made to contact at 100 degrees C of ****-ized hydrogen 1 time amount. When transmission electron microscope observation of this substrate was carried out, the gas endocyst carbon nanotube of a carbon nanotube which entered only inside most was checked for ****-ized hydrogen.

[0021] (Example 7) It carried out using sodium by conducting alkali metal the same experiment as an example 1. In order that sodium might react easily with oxygen in air, it made the carbon nanotube, impressed the direct-current high voltage to inter-electrode only for 5 seconds after that, and made corona discharge cause between a carbon electrode and a carbon nanotube with the arc discharge equipment which equipped sodium beforehand. 50 nanometers of sodium introduced beforehand after this were vapor-deposited with the resistance heating method. After heat-treating a carbon nanotube at 150 degrees C among argon atmosphere by this condition, when transmission electron microscope observation was carried out, the alkali-metal endocyst carbon nanotube of a carbon nanotube which entered only inside most was checked for sodium.

[0022] (Example 8) Since the carbon nanotube is carrying out the configuration where GURAFAITOSHI-TO without a defect was rounded off and does not include any structures other than carbon 6 membered-ring, it is the high crystal of integrity very much. sp2 which the dangling bond by the carbonaceous pi orbital has appeared in radial [the] in the comparatively small carbon nanotube of a bore, and is known for graphite sp3 known for a diamond rather than mold association It is close to mold association. The dangling bond of this inside serves as an adsorption site to an unstable gas molecule, and can also consider the catalysis to disassembly of a molecule suddenly. Therefore, it is thought that the location of the quality of a foreign matter to which decomposition will be promoted if the gas for semi-conductor formation suitable in a tube is introduced, and it decomposes and sticks is also arranged according to the configuration of a carbon nanotube. Moreover, since the homogeneity of the overall diameter of the semi-conductor which ****, and a path, and precision are determined by the integrity inside a tube,

they can form the semi-conductor of the NANOME-torr size according to the inside configuration of a tube.

[0023] The example which produced the silicon crystal in the carbon nanotube is explained. The carbon nanotube used for the experiment was made by using a carbon rod with a diameter of 10mm as a cathode in the helium ambient atmosphere of 500Toor(s), and making it discharge by direct-current 20V as a positive electrode using a 6mm carbon rod. The carbon nanotube was taken out from a part for the core of the deposit of the carbon which carried out the volume to the cathode at about 30% of yield. Thus, the made carbon nanotube with a bore of about 2 nanometers is placed into a heat treating furnace, and it exhausts to 10-7Torr with evacuation equipment first. After that, hydrogen gas is introduced until it is set to 1Torr, and the inside of a furnace is set as 1000 degrees C, and is left for 2 minutes. After exhausting the inside of a furnace to 10-7Torr again, temperature of a furnace was made into 750 degrees C, 50Torr installation was carried out and the disilane was processed for 30 minutes. After a disilane enters in the carbon nanotube which carried out the open pipe by hydrogen processing, it is pyrolyzed and produces a silicon solid-state crystal here. In order to carry out an open pipe, hydrogen was used here, but if atomic hydrogen with activity higher than hydrogen is used, it will be thought all the time at low temperature rather than 1000 degrees C that there is the same effectiveness. The hydrogen generated with disilane decomposition is emitted from the carbon nanotube edge or the wall surface. Therefore, the matter of the inside obtained after processing is silicon itself, and can do a single dimension thin line with the silicon semi-conductor created according to the bore of a tube. When observed with the transmission electron microscope after creation, it was checked that the nature endocyst carbon nanotube of a foreign matter with which the silicon of a carbon nanotube which is the quality of a foreign matter was most introduced only into the inside tube is made. In addition, according to transmission electron microscope observation, the lattice constant of the connoted silicon was large a little compared with it of three-dimension bulk. This is considered to be because for spacing of the dangling bond of the carbon nanotube inside to have changed the lattice constant of a silicon crystal.

[0024] When silicon endocyst carbon nanotubes were collected and having been excited by the light of an Ar ion laser (5145 on-guru fatty tuna - MU), strong, infrared luminescence was obtained. With three-dimension bulk silicon, although forbidden, by making it a thin line, the prohibition rule is broken, strong luminescence was obtained and the

indirect transition type of band structure to luminescence is considered. Moreover, it is idea ** that this prohibition rule became loose further since it had the crystal structure and the lattice constant from which three-dimension bulk differs since the carbon nanotube is used as the substrate.

[0025] (Example 9) They are triethylgallium and arsine ********** about the same experiment as an example 8. The carbon nanotube put on the grid substrate was put into the reaction container, once it exhausted to 10-6Torr, the temperature of the carbon nanotube on a grid substrate was raised to 620 degrees C, and it introduced, adjusting triethylgallium and an arsine so that it may be set to 1:3 from a separate inlet by stoichiometry, and maintained at 50Torr. After making it react in this condition for 20 minutes, when it observed with the transmission electron microscope, it was checked that the nature endocyst carbon nanotube of a foreign matter with which the gallium arsenide of a carbon nanotube which is the quality of a foreign matter is most contained only in an inside tube is made. In addition, it is expected that the lattice constant of the gallium arsenide investigated by electron diffraction in this case is larger than 5.65A known for bulk, and the methyl group or methane generated in the introduced gas reaction time is contained.

[0026] (Example 10) The same experiment as an example 9 was conducted, irradiating 210-nanometer light during a reaction. Consequently, the same result as having been required of the example 9 620 degrees C was obtained at 350 degrees C.

[0027] (Example 11) In GURAFAITOSHI-TO by which the carbon nanotube is known conventionally, round-off ****** is carried out and the electrical conductivity of carbon nanotube shaft orientations is considered to be very high from the analogy of graphite. Moreover, the integrity of the crystal of a carbon nanotube is also considered with making the mobility of the carrier increase greatly.

[0028] Since the metal arranged at the core of the nature endocyst carbon nanotube of a foreign matter obtained by this invention moves a charge between the innermost carbon cylinders, originally it can give the high carrier concentration which it does not have to a carbon nanotube. The carrier (****** is an electron hole) by which induction was carried out to the nature endocyst carbon nanotube of a foreign matter by making it like has high mobility from the integrity of a carbon nanotube crystal, therefore it is predicted that the electrical conductivity related to the product of carrier concentration and mobility becomes very high. Although aluminum or its alloy is used for

current LSI wiring, if copper is used, about 1/will become resistance of 2 at a room temperature. In the nature endocyst carbon nanotube of a foreign matter by this invention, it is expected that the electric resistance becomes 1/10 or less [of copper].

[0029] Moreover, association of the shaft orientations of a carbon nanotube is the same association as a diamond, and the bonding strength is very high. Therefore, it is expected that there cannot be almost no distortion, diffusion of the carbon atom by temperature (in the usual electrical-part use range), migration, and destruction. Moreover, if electric resistance with the carbon nanotube by which carrier induction was carried out to the central metal section is compared, since it is far low, as for most currents, the direction of a carbon nanotube will flow a carbon nanotube top. Therefore, it is predicted that generation of heat by metaled resistance, electromigration, and a stress migration can also be prevented.

[0030] Drawing 2 shows the example which wired inter-electrode with the metal endocyst carbon nanotube. The carbon nanotube 24 (the bore of about 10 nanometers, outer diameter of about 15 nanometers) produced with arc discharge equipment on the big metal electrodes 22 and 23 using the lead on the substrate 21 for making connection with an external measurement machine is arranged. After carrying out spreading desiccation of the organic solvent which distributed the carbon nanotube in fact on the substrate 21 with the lead electrodes 22 and 23, it introduces into a vacuum scanning tunneling microscope, and by migration of the needle of a vacuum scanning tunneling microscope, and impression of electric field, a carbon nanotube is moved and it puts on a desired location like drawing 2 . A substrate is moved to vacuum-heat-treatment equipment after this, and 10Torr installation of the oxygen is carried out first, and 300 degrees C is processed for 2 minutes, it is again made a vacuum after that, and 350 degrees C and heat treatment for 20 minutes are performed. By this processing, the lead electrodes 22 and 23 become melt-like, and invade into the nanotube inside. If it returns to a room temperature, an inside metal and an electrode will paste up and wiring will be done. In addition, although oxygen gas was used here for the carbon nanotube open pipe, if ozone with activity higher than oxygen is used, it will be thought that processing temperature required for an open pipe is made still lower.

[0031] Thus, inter-electrode resistance of the obtained circuit is the same as that of what vapor-deposited aluminum by 1000A width of face on the same substrate, and considering being smaller than the case of aluminum a single figure, the size of a lead endocyst carbon nanotube is

understood that resistance of the lead endocyst carbon nanotube of this invention is far low. Moreover, in the case of the lead endocyst carbon nanotube, degradation by high current consistency impression was not seen, either. Furthermore, when this wiring was lowered to liquid helium temperature (4.2K), resistance would fall rapidly and the wiring part would be in the superconductive state. It is thought that the lead which is an endocyst metal would be in the superconductive state.

[0032] (Example 12) That bore is usually 5-10 nanometers very small, the carbon nanotube of a twist is small much in the magnitude of the magnetic domain of the magnetic substance usual in this size, therefore a magnetic-substance endocyst carbon nanotube is considered to be the so-called single domain particle, and it is not accompanied by migration of a magnetic domain to magnetization, but big holding power is acquired. Moreover, if the shaft of a magnetic-substance endocyst carbon nanotube is arranged perpendicularly, it will be thought that the vertical-magnetic-recording medium of high density is extremely made from the anisotropy.

[0033] In addition, since the spin of a magnetic element will serve as the so-called superparamagnetism in response to thermal turbulence and coercive force will be lost if the bore of a carbon nanotube becomes 1 - 2 nanometers, when using as a record ingredient using magnetism, it is desirable to use a carbon nanotube with a bore of about 10 nanometers as a raw material.

[0034] Drawing 3 is the magnetic thin film which arranged in on a glass substrate 31 the nature endocyst carbon nanotube of a foreign matter which contains a gadolinium and cobalt as a magnetic-substance endocyst carbon nanotube. After vapor-depositing a gadolinium to a carbon nanotube, it heat-treats at 1350 degrees C, and cobalt is vapor-deposited further after that and it heat-treats at 1600 degrees C. After this, according to centrifugal separation, the nanotube of fixed weight is separated and an organic solvent is distributed. Applying a magnetic field on a glass substrate after this, the solvent containing the magnetic-substance endocyst carbon nanotube 32 was applied and dried, and the magnetic thin film was obtained. Usual GdCo2 when the magnitude of magnetization was measured about this thin film Twice as many magnetization as this is ******.

[0035]

[Effect of the Invention] This invention stuffed the quality of a foreign matter into the hole of the hollow which exists at the core of a carbon nanotube. It is what offers new matter called the nature endocyst carbon nanotube of a foreign matter, and its process. Such matter As an

electronic device and the basic component of the record ingredient of high density with the very high mobility reflecting the integrity of the basic material of the device using the quantum size phenomenon produced in a NANOMETORU field, or the structure of a carbon nanotube The activity as a new electronics material is expected, and the application as new materials can be expected also in a chemical-industry-side face, and the industrial usefulness is very high.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing having shown the nature endocyst carbon nanotube of a foreign matter of this invention.
[Drawing 2] Drawing which used the metal endocyst carbon nanotube by this invention as a lead inter-electrode wiring material
[Drawing 3] Drawing which arranged the magnetic-substance endocyst carbon nanotube by this invention in on a substrate, and was used as a magnetic-recording ingredient
[Description of Notations]
1 Carbon Nanotube
2 Lead
21 Substrate
22 Lead Electrode
23 Lead Electrode
24 Lead Endocyst Carbon Nanotube
31 Substrate
32 Magnetic-Substance Endocyst Carbon Nanotube
